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JEFFREY PINE AND VEGETATION OF THE SOUTHERN MODOC NATIONAL FOREST

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Jeffrey pine (*Pinus jeffreyi* Grev. & Balf.) ranges the length of California in forested areas and extends into southern Oregon and northern Baja California (Griffin and Critchfield, 1972). It occurs in several forest and woodland communities but also forms a fairly distinctive Jeffrey pine forest type east of the Sierra Nevada–Cascade ranges (Society of American Foresters, 1954). Jeffrey pine forests reach widespread development near the Owens River headwaters and Mono Lake and in eastern Plumas and Lassen counties. Elsewhere, Jeffrey pine occurs as an element of the mixed conifer forest (Griffin and Critchfield, 1972), a vegetation type roughly equivalent to the yellow pine forest of Munz and Keck (1949) and to several forest types recognized by the Society of American Foresters (1954). In some of the latter, Jeffrey pine and ponderosa pine (*Pinus ponderosa* Laws.) mingle freely. Such forests are classed as ponderosa pine forest types without particular analysis, even though Jeffrey pine sometimes predominates.

As an element of mixed conifer forests, Jeffrey pine reaches its northern limit in the Siskiyou Mountains of southern Oregon (Whittaker, 1960; Franklin and Dyrness, 1973). To the south, it has generally been included in forest communities dominated by ponderosa pine (Munz and Keck, 1949; Griffin and Critchfield, 1972; Horton, 1960; Minnich, 1976; Thorne, 1976). However, Jeffrey pine increases in importance toward higher elevations and toward the interior (Haller, 1962; Griffin and Critchfield, 1972), and forested areas dominated by Jeffrey pine to the virtual exclusion of ponderosa pine have been noted in the Sierra Nevada of Kern County (Twisselman, 1967) and Fresno County (Klyver, 1931), on Mt. Pinos (Vogl and Miller, 1968), in the San Gabriel Mountains (Thorne, pers. comm.), and in the San Bernardino Mountains (Vasek, 1966). Furthermore, *P. jeffreyi* dominates forests in the peninsular ranges (Santa Rosa Mountains, Laguna Mountains) of southern California. Whereas, *P. ponderosa* reaches a southern limit near Cuyamaca Lake in San Diego County, California (Haller, 1959), *P. jeffreyi* continues south to the Sierra Juarez and the Sierra San Pedro Martir of Baja California where it is a dominant in forested areas (Haller, pers. comm.).

Several questions arise concerning the community definition, composition, and ecology and the phytogeographic history of Jeffrey pine forests in the south relative to those in the north and of such forests relative to mixed conifer forests. Accordingly, a long-range program of vegetation sampling was initiated in the northern Jeffrey pine forests to provide a data base from which north–south comparisons and interpretations might be made. That project is a long way from fruition. However, shortly after sampling several plots in the Modoc National Forest, several vegetation–soil maps (U.S. Forest Service, 1953a) for the sampled area came to my attention. These maps are part of a series prepared by the State Cooperative Soil–vegetation Survey (U.S.D.A. Forest Service, 1958). Most of the available vegetation–soil map coverage applies to the coast range forests and coverage is sparse for the region east of the Sierra Nevada–Cascade ranges. Consequently, the coincidence in sampling areas is fortuitous.

My few ground samples could be correlated with broad scale coverage of more than 200 sections (520 km^2) and an opportunity was presented to address several general questions regarding species composition and species associations, and the environmental and distributional relations of northern Jeffrey pine forests. Consideration of these parameters may lead to a better understanding of the northern Jeffrey pine forests and provide a focal reference for investigation of those to the south.

This paper characterizes a Jeffrey pine forest near the northern limit of that forest type and draws relationships to comparable forests farther south.

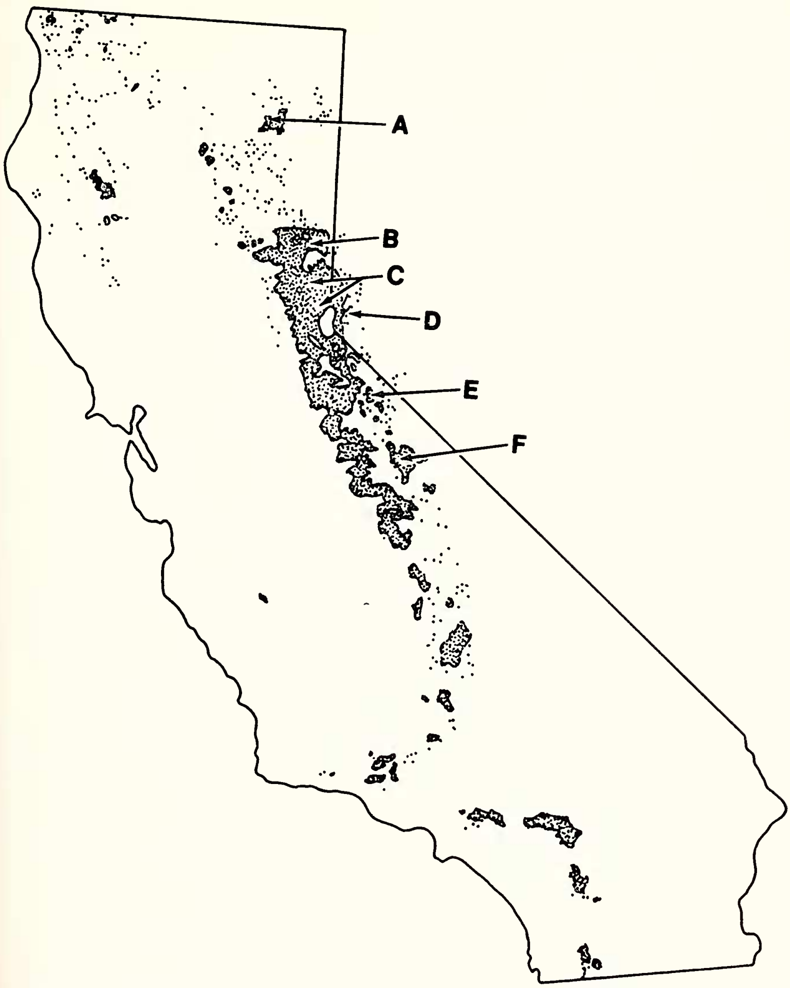

Fig. 1. Map showing the distribution of *Pinus jeffreyi* and the locations of sampling areas in California: A, southern Modoc National Forest; B, Plumas N.F.; C, Tahoe N.F.; D, Toiyabe N.F. (Nevada); E, Devils Gate Pass; F, Deadman Summit. Adapted from Griffin and Critchfield, 1972.

Methods

This study employed two approaches: a simulated aerial point sampling based on vegetation–soil maps and direct ground sampling.

Vegetation–soil maps were compiled by the U.S. Forest Service (1953a) from aerial photographs plus direct ground observations and supplemental soil samples. Vegetation–soil maps resemble a jig–saw puzzle in which units of irregular shape and variable size are each coded for characteristics of the constituent vegetation and soil types (Colwell, 1974). Each cover element comprising more than 20% of the total cover, and the included species, each comprising at least 20% of the cover in that element, is listed in order of decreasing cover value (U.S. Forest Service, 1953b). Soil series, depth, texture and exposure are coded for each unit. Thus a large body of semi–quantitative descriptive information is available for a significant segment of forest.

Vegetation–soil map coverage for the Modoc National Forest and for all northeast California includes only that portion of the Big Valley District, Modoc National Forest (Fig. 1), located in Lassen County, south of the Modoc County town of Adin. The National Forest Boundary is irregular and encloses a mapped area of 208 full sections and parts of 27 other sections. Vegetation of this forest segment was sampled as follows:

1) A series of 10 transects was made from west to east across alternate tiers of sections. The first transect started southeast of Adin, and south of the county line, with section 36, R9E T39N, and included 10 consecutive sections. The last transect, 29 km to the south, started with sections 31 to 34, R8E T36N, skipped 11 private, unmapped sections, and ended at sections 34 and 35, R10E T36N, for an interrupted transect of 6 sections.

2) Each transect consisted of 2 tracks parallel to the north section line and located respectively ¼ and ¾ of the way to the south section line.

3) Five sample points were equally spaced along each track, starting at the west edge of each section, providing 10 sample points per section.

4) The vegetation–soil unit at each sample point was recorded.

5) The accumulated data for 105 full sections (1050 sample points) were tabulated to yield frequency data for each major species and several non–specific cover elements (e.g. bare ground).

Direct ground samples were taken from the Modoc, Plumas, Tahoe and Toiyabe National Forests (Fig. 1) during Sept. and Oct. 1974. Sampling areas potentially dominated by Jeffrey pine were selected using a published range map (Griffin and Critchfield, 1972) before going into the field. In each area sample points were located at 100–pace intervals (about 160 m) along a line–of–sight transect established on a diagonal to the general slope. Sample points were used to center temporary circular sample plots of 100 m^2. In each plot dbh was recorded by species for each tree taller than 2 m; height was recorded by species for each tree shorter than 2 m; and 2 diameters were recorded by species for each shrub. Basal area for trees and crown cover for shrubs were calculated from half–diameters by assuming circular shapes. For non–circular shrubs, the longest diameter (a) and a perpendicular short diameter (b) were measured and the crown cover area calculated from $A = \pi\ (a/2 \cdot b/2)$. For prostrate or sprawling shrubs such as *Ceanothus prostratus* and *Symphoricarpos acutus*, density was arbitrarily assumed to be one plant per plot and ground cover was estimated visually for each plot.

Crown cover for Jeffrey pine was estimated from basal area. The crown cover/basal area for 10 trees on which both parameters were measured ranged from 30 to 165; 100 was selected as representative. The same conversion factor was applied to other tree species but possible error was not estimated.

Five to 8 plots were scored in each sampling area. Data include density, cover, and frequency for each species. Relative density, relative cover, and relative frequency for each species were calculated and summed to obtain an Importance Value (Mueller-Dombois and Ellenberg 1974), a convenient statistic for comparing forest stands in different areas. In addition, exploratory data, gathered during preliminary method evaluations in 1972, were included to characterize forests in Mono County (Fig. 1).

Individual pine trees sometimes posed problems in identification by manifesting several traits from two species. These were listed as hybrid derivatives under the species most closely resembled.

In the Modoc Forest, *P. ponderosa* includes 7 putative hybrid derivatives, and *P. jeffrey* includes 6 putative hybrid derivatives. In the Plumas Forest, 6 hybrid derivatives are included in *P. ponderosa* and 2 in *P. jeffreyi*. In the Tahoe region, all trees observed were typical Jeffrey pine. However, *Pinus washoensis* occurs nearby (Haller, 1961), and it is possible that some Washoe pine data is included under Jeffrey pine in that area.

Identity of the juniper subspecies posed another problem. The southern Modoc Forest is at the transition between the usually dioecious, forest-dwelling *Juniperus occidentalis* ssp. *australis* and the slightly smaller, commonly monecious, woodland forming *J. occidentalis* ssp. *occidentalis* (Vasek 1966, Vasek and Thorne 1977). This paper deals primarily with *J. o. australis* but some influence of *J. o. occidentalis* in the open woodland areas cannot be ruled out.

Results and Discussion

Vegetation structure based on vegetation map data. Vegetation of the southern Modoc National Forest consists of a mixture of tree, shrub, and herbaceous species arranged on and around a series of small volcanic mountains. Topographic relief of the region ranges from elevations of about 1280 m at Adin to about 1950 m at the top of Hayden Hill. The 3 vegetational phases (forest, woodland and scrub) are identified on the basis of whether trees or shrubby elements dominate, or whether only shrubby species occur. The 3 phases are arbitrarily defined for descriptive convenience since forests grade into woodlands and woodlands into scrub.

Forests occupy about 39% of the area (Table 1) based on frequency of sample points in forest areas. Woodland occupies about 43%, and scrub or brush vegetation about 17%. In general, then, the mapped vegetation within the National Forest boundary is relatively open, more than 60% having no or rather sparse tree cover.

Table 1. Frequency of Species and Cover Elements in Three Sub-groups Based on Vegetation Structure. I, shrubs only; II, shrubs dominant; III, trees dominant. % = percent occurrence in total sample; N = number of sample points. For *Abies concolor*, the symbol W is used for convenience, rather than $\hat{W}$.

Species or element	Symbol	Observed Frequency				
		I	II	III	Total	%
Trees						
Abies concolor	W	—	8	82	90	8.6
Calocedrus decurrens	I	—	11	78	89	8.5
Pinus ponderosa	Y	—	140	325	465	44.3
Pinus jeffreyi	J	—	269	342	611	58.2
Quercus kelloggii	B	—	17	10	27	2.6
Juniperus occidentalis	Jo	—	292	71	363	34.6
Woody shrubs						
Ceanothus velutinus	Cv	5	3	5	13	1.2
Ceanothus prostratus	Cpo	1	43	72	116	11.0
Arctostaphylos patula	Ap	50	105	43	198	18.9
Cercocarpus ledifolius	Cl	62	215	115	392	37.3
Amelanchier pallida	Aa	26	9	1	36	3.4
Prunus emarginata, P. demissa	Pe,Pd	3	1	—	4	0.4
Symphoricarpos vaccinoides	Sar	—	3	2	5	0.5
Brush						
Artemisia tridentata	Atr	82	254	61	397	37.8
Purshia tridentata	Pt	59	183	51	293	27.9
Chrysothamnus nauseosus	Chn	15	57	13	85	8.1
Chrysothamnus viscidiflorus	Chv	8	12	—	20	1.9
Artemisia arbuscula	Aar	49	82	11	142	13.5
Artemisia cana	Arc	3	—	—	3	0.3
Herbs and other						
Wyethia mollis	Wm	4	32	51	87	8.3
Grasses and herbs	Gr	130	303	164	597	56.9
Bare ground	Ba	115	222	232	569	54.2
N		183	454	413	1050/4602	
%		17.4	43.2	39.3		

Areas of dense forest grade into less dense forest patches, some with a shrubby understory or intermittent open or shrubby areas. Open forests grade into woodlands. Vegetation structure appears to be influenced by, or correlated with, soil characteristics. Forests preferentially occur on north slopes with deep soil and low surface rock cover (Table 2). Woodland tends to occur on south slopes with greater surface rock cover and soil of intermediate depth. Scrub vegetation occupies shallow soils (Table 2).

TABLE 2. FREQUENCY OF SEVERAL SOIL CHARACTERISTICS IN THREE VEGETATION STRUCTURAL SUBGROUPS (as in Table 1). N = number of sample points; NC = number of sample points with unclassified soil. Surface rock categories R0, R4, R3, R2 and R1 respectively indicate 0–5, 5–20, 20–50, 50–80 and 80–100% imbedded large rocks or bed rock; average surface rock cover is calculated from class mid-point values. Soil depth is indicated in feet, the letter s indicating stones equal to about 1 ft of soil; soil series with arbitrary numbers.

	I	II	III	Total	%
N	183	454	413	1050	
NC	18	4	1	23	
Aspect					
North	67	130	256	453	44.1
South	98	320	156	574	55.9
Surface rock (Ave. = 14.9% surface rock cover)					
R0 (0–5%)	64	129	249	442	43.0
R4 (5–20%)	48	176	109	333	32.4
R3 (20–50%)	45	114	42	201	19.6
R2 (50–80%)	8	31	10	49	4.8
R1 (80–100%)	—	—	2	2	0.2
Soil depth (average = 2.43)					
5	—	—	17	17	1.7
5s	—	—	31	31	3.0
4	7	22	26	55	5.4
4s	10	25	188	223	21.7
3	8	20	10	38	3.7
3s	7	148	93	248	24.1
2	11	19	1	31	3.0
2s	86	154	35	275	26.8
1	2	4	—	6	0.6
1s	34	58	11	103	10.0
Soil series					
714	28	129	107	264	25.7
720	45	147	197	389	37.9
722	11	54	80	145	14.1
761	3	10	—	13	1.3
763	6	5	—	11	1.1
765	28	44	9	81	7.9
776	39	38	10	87	8.5
777	1	16	1	18	1.8
Misc.	4	7	8	19	1.9

The several soil series are arbitrarily numbered (Colwell, 1974) and several of the major soils and their frequency distribution are listed in Table 2. Soil 720, a loam with good permeability, good drainage and slight acidity is most frequent. Other soils differ as follows: loam 722 is neutral with excessive drainage; gravelly–sandy loam 714 drains excessively as does loam 765; stony loam 766 and stony–sandy loam 777 drain poorly and have slow permeability; sandy loam 763 has imperfect drainage; and clay loam 761 is alkaline with slow permeability.

TABLE 3. AVERAGE FREQUENCY OF SOUTH-FACING ASPECT, SURFACE ROCK COVER, AND DEPTH OF SOILS ON WHICH THE INDICATED SPECIES OR COVER ELEMENTS OCCUR. Notations as in Tables 1 and 2.

	South aspect	Surface rock	Soil depth
	Av. %	Av. %	Av. ft.
Trees			
W	22.2	4.7	3.6
I	24.7	8.9	3.2
Y	38.4	7.6	2.9
J	47.7	9.7	2.9
B	40.7	14.1	2.1
Jo	77.7	25.9	1.7
Woody shrubs			
Cv	7.7	7.3	3.5
Cpo	47.8	10.5	3.0
Ap	55.3	11.8	2.4
Cl	52.8	13.5	2.4
Aa	44.4	10.8	1.7
Brush			
Atr	51.0	12.7	2.2
Pt	51.5	14.1	2.1
Chn	76.2	15.7	2.2
Chv	62.1	9.3	1.8
Aar	83.2	41.7	1.0
Herbs and other			
Wm	57.5	9.7	2.6
Gr	62.5	17.3	2.2
Ba	59.7	20.8	2.2

Vegetational composition based on vegetation maps. The 21 species observed, plus grasses (including associated herbs and bare ground), are grouped according to growth form in Table 1.

Pinus jeffreyi has the highest frequency followed by *P. ponderosa, Artemisia tridentata, Cercocarpus ledifolius, Juniperus occidentalis,* and *Purshia tridentata*. The non–specific cover elements, grasses and bare ground, also have high frequencies which total about 25% of all the frequency occurrences (= relative frequency), and emphasize the open nature of the vegetation. The high frequency of bare ground in forested areas doubtless reflects the nature of the geology with its exposed volcanic ridges, peaks, and abrupt slopes.

Tree species array along a gradient initially identified on the basis of soil depth (Table 3). *Abies concolor* occurs on soils averaging 110 cm in depth whereas *Juniperus occidentalis* occurs on soils averaging 52 cm. Other tree species fill in the gradient in the sequence listed in Table 3.

The same species follow a similar gradient in surface rock cover from about 5% average surface rock for soils of *A. concolor* to 26% for *J. occidentalis* (Table 3). However, the internal gradient sequence differs

Table 4. Relative Frequency of Plant Species and Cover Elements on Several Common Soils.

	Soil series								
	720	722	714	765	776	777	763	761	Other
Trees									
W	67	30		1					2
I	85	8	3	1					2
Y	47	20	30	1					2
J	46	20	31	1	1				1
B	63	15	4	11					7
Jo	28	11	21	15	13	5	4		3
Woody shrubs									
Cv	69	8	23						
Cpo	90	1	8	1					
Ap	79	14	6						1
Cl	47	20	27	4					2
Aa	67	8	8	6					11
Brush									
Atr	38	13	29	18	1				1
Pt	43	9	23	20	3				2
Chn	17	28	26	27	1				1
Chv	50	3	43						3
Aar	3		2	3	59	13	8	7	5
Herbs and others									
Wm	86	3	1	9					
Gr	19	13	35	13	13	3	2	2	1
Ba	42	10	16	8	15	3	2	2	1

slightly from the soil depth sequence in that soils of *Calocedrus* have a little more surface rock, on average, than do soils on which *P. ponderosa* occurs.

A pattern of nearly parallel soil gradients is extended to the parameter of slope aspect. This gradient ranges from a 22% ocurrence of *A. concolor* on south facing soil formations (= 78% preference for north aspects) to 78% preference for south aspects for *J. occidentalis*. On slope aspect, however, *Quercus kelloggii* assumes a gradient sequence position close to *P. ponderosa* rather than between *P. jeffreyi* and *J. occidentalis* as observed in the 2 other gradients.

All tree species grow on soil 720 and usually one or more other soils. *Calocedrus* is most frequent on soil 720, followed by *Abies* and then *Q. kelloggii*. Most notably, *J. occidentalis* occurs on a wide range of soil types, with significant occurrence on heavy–textured soils such as 776 and 777 (Table 4).

Woody shrub species assort along a soil depth gradient (Table 3) closely parallel to that for tree species. Along a gradient from deep to shallow soils, *Ceanothus velutinus* is followed by *C. prostratus, Arctostaphylos patula, Cercocarpus ledifolius,* and *Amelanchier pallida.*

TABLE 5. SOIL CHARACTERISTICS ALONG AN ASSOCIATION GRADIENT IDENTIFIED ON THE BASIS OF RELATIVE DOMINANCE OF JEFFREY PINE VS. PONDEROSA PINE AT ONE EXTREME AND MOUNTAIN JUNIPER AT THE OTHER. Relative dominance is indicated by the sequence of species symbols.

Association	N	Rel. Freq.	South aspect %	Surface rock Av. %	Soil depth Av. ft.	Soil series 720	714	722	765	776	777
Y	39	4.2	33.3	6.7	3.2	92	5	—	—	—	—
YJ	308	33.3	33.8	5.6	3.4	41	33	24	—	—	—
JY	118	12.8	52.1	10.7	2.7	50	28	17	—	—	—
J	97	10.5	52.6	8.1	2.6	47	38	14	—	—	—
JoJy	59	6.4	48.3	12.6	2.4	43	28	22	—	—	—
JoJ	88	9.5	85.2	21.7	1.9	57	23	15	—	—	—
Jo	216	23.3	82.6	31.5	1.4	12	19	—	23	21	8

The surface rock cover gradient for woody shrubs is less regular and less extensive than for trees. *Ceanothus velutinus* grows on soils with about 7% surface rock. Other shrub species form a group with soil surface rock cover averages ranging from 10.5–13.5%

A stepped gradient in slope aspect is apparent for soils on which shrubs occur (Table 3). A strong preference (92%) for north aspects places *C. velutinus* in a class by itself. The other shrub species array near neutral values (i.e. 50%) with *A. pallida* and *C. prostratus* showing slight preference for north aspects and *Arctostaphylos* and *Cercocarpus* showing slight preference for south.

Shrubs closely parallel the pattern described for trees with regard to soil type. Generally a decreasing occurrence on soil 720 follows a slightly different species sequence than was observed in the soil depth gradient (Table 4). *Ceanothus prostratus* is most frequent on soil 720 whereas *Cercocarpus ledifolius* is least frequent.

Soft shrub or "brush" species occupy similar gradients, but in contrast to trees and woody shrubs, the soil depth gradient range is lower, the range of surface rock cover higher, and the range of preference for soils with south aspect greater (Table 3). Generally, *Artemisia tridentata* and *Purshia tridentata* occur on the most favorable of the "brush soils". *Artemisia arbuscula* characteristically occupies heavy soils and is essentially excluded from soil 720 (Table 4).

The cover elements conferring an open character to the vegetation, i.e., *Wyethia mollis,* grasses and bare ground, usually occupy soils that generally face south (Table 3). Those are somewhat shallow but deeper than most of the "brush" soils. Surface rock cover is moderate for soils of *W. mollis* and rather extensive for grasses and bare ground.

Table 6. Crown Cover and Vegetation Characteristics of Perennial Species in 5 Sample Areas in Modoc National Forest Having Jeffrey Pine as a Dominant Element. Locations listed in Table 8. D = density; F = frequency; C = crown cover in m^2; I.V. = importanc value derived from summation of *relative* D, F and C; * = cover estimatd (or partly). ** = *Ribes viscosissimum* at area III.

Species	Sample area					Total			
	I	II	III	IV	V	D	F	C	I.V.
Abies concolor	19.18					13	1	19.18	3.7
Calocedrus decurrens	14.22					3	1	14.22	2.0
Pinus ponderosa	30.59	312.48	0.64	48.62		62	15	392.33	40.2
Pinus jeffreyi	77.58	202.74	185.50	285.34	118.20	114	25	869.36	79.2
Juniperus occidentalis	15.36		32.73	102.40	176.54	44	17	327.03	35.7
Amelanchier pallida	0.68		0.62	0.30		13	9	1.60	8.9
Arctostaphylos patula			0.13			2	1	0.13	1.1
Artemisia tridentata	10.87		..15.93			155	7	26.80	29.9
Cercocarpus ledifolius	76.84	2.37	34.57	81.49	73.39	100	24	268.66	46.6
*Ceanothus prostratus**	4.00	44.00	14.00	0.50		8	8	62.50	10.4
Ceanothus velutinus				0.20		1	1	0.02	1.0
Chrysothmnus nauseosus			0.84			5	2	0.84	2.3
Penstemon deustus				0.03		1	1	0.03	1.0
Purshia tridentata		2.77	15.12	0.61	2.53	107	13	21.03	26.9
*Ribes velutinum***			0.89	1.91		8	5	2.80	5.1
Rosa californica			8.81			13	1	8.81	3.2
Symphoricarpos vaccinoides			0.27			15	1	0.27	3.1
Total	249.32	564.36	310.05	521.22	370.66	664	132	2015.61	300.3
Number of plots	6	6	8	7	6		33		
Average cover	41.6	94.1	38.8	74.5	61.8		61.08		
Average tree cover	26.2	85.9	27.4	62.3	49.1		49.16		

Jeffrey pine gradient segment. Since Jeffrey pine comprises a major focus in this study, its position in a gradient relative to other species was examined in detail. Seven association categories were identified (Table 5) based on relative dominance of *P. jeffreyi*. *Pinus ponderosa* and *Juniperus occidentalis* occur at either end of this gradient segment. *Pinus jeffreyi* occurs in the 5 intervening categories according to its increasing dominance relative to *P. ponderosa* (steps 1–4) and its decreasing dominance relative to *J. occidentalis* (steps 4–7).

In this analysis, mixed forests dominated by *P. ponderosa* are most frequent (Table 5), followed by *Juniperus* woodlands. Unmixed stands of Jeffrey and ponderosa pines are much less frequent than those of western juniper, reinforcing other indications concerning the general dry, open nature of the southern Modoc forest. Even though selection of study area was based on Jeffrey pine dominance, unmixed Jeffrey pine forests occupy only a narrow band along the available gradient (Table 5).

On this gradient, *P. ponderosa* occupies deep soils with little surface rock and shows definite north aspect preference. *Juniperus occidentalis* occupies shallow soils with much surface rock and shows strong south aspect preference. Unmixed stands of ponderosa pine strongly correlate with soil 720. Jeffrey pine and pondeosa–Jeffrey stands occur on soil 720 but more often on soils with excessive drainage. Jeffrey pine dominance relative to ponderosa pine correlates with south slope preference, greater surface rock cover, and shallow soils. *Juniperus occidentalis* occupies a variety of soil types especially, where it occurs alone, the heavy soils (Table 5). Its dominance relative to Jeffrey pine correlates with greater south slope preference, greater surface rock cover, and shallower soils. Soil preferences are clear but broad overlapping ranges of tolerance permit cohabitation over considerable area.

Vegetation of the southern Modoc Forest based on ground samples. This study also involved comparison of the southern Modoc Forest with other northern California forests having Jeffrey pine as a dominant element. Ground–level vegetation samples from 5 forest areas of the southern Modoc Forest indicate an average cover of 61% and an average tree cover of 49% (Table 6). The 5 tree species and 12 shrub, brush and suffrutescent species observed suggest low species diversity. The most important species, on the basis of Importance Values, include 3 trees and 4 shrubs in the sequence *Pinus jeffreyi, Cercocarpus ledifolius, Pinus ponderosa, Juniperus occidentalis, Artemisia tridentata, Purshia tridentata* and *Ceanothus prostratus* (Table 6). Considerable variation in importance values suggests that few species are dominant in the region.

The occurrence of several vegetational phases is apparent from the variation among sample areas (Table 6). Few species were observed in samples areas II and V; each was dominated by 2 tree and one shrub species. However, a mesic forest of ponderosa and Jeffrey pine occurs in

Table 7. Location of Ground Samples in a Segment of the Southern Modoc National Forest and Correlation with Map Vegetation Units. Species codes are listed in Table 1 * = probable hybrid derivative. ( ) indicates present, but low in cover.

Sample Area		1 Ash Creek	2 Foster Spring	3 Hayden Hill	4 Johnson Mill	5 Willow Ridge
Section		5	9	31, 30	1, 2	17
Range		10E	10E	10E	10E	10E
Township		38N	37N	37N	37N	37N
Map Vegetation Codes		Cl Ba J Y	Y J Ba	Gr Ba Atr Y J	Cl Ba Jo J	Cl Gr Jo J
		W J Ba		Gr Ba Cl J	Y J Ba Gr	Cl Gr Jo JY
		Ba Y J Gr Chn Atr				
Ground Sample Vegetation Codes	1	I J Y Cl	J Y	J	J	Jo
	2	Cl Atr	Y Cpo	J Atr	Cl	Cl (JY)*
	3	Cl J Y	Y Cpo	J	Jo	Jo Cl
	4	Cl J (Jo)	Y	J (Atr)	Cl J	J Cl
	5	Cl J (Y)	Y	Jo J	Cl J	J Cl Jo
	6	W Y	J (Y)	Pt (JoJ)	J Y	Jo
	7			Cl (Pt)		
	8			J Cl Cpo		
Summation						
Map code		J Cl Y W Chn Atr Ba Gr	Y J Ba	J Cl Atr Y Ba Gr	J Cl Jo Y Ba Ba	Cl Jo JY Gr Gr
Ground code		J Cl Y W I Atr Ba Ba	Y J Ba	J Cl Jo Atr Pt Ba Ba	J Jo Cl Y Ba Ba	JoJ Cl Ba Ba

area II whereas a drier more open forest–woodland of *J. occidentalis, P. jeffreyi* and *C. ledifolius* occurs in area V.

Greater diversity of species in areas I, IV, and especially III apparently correlates with considerable local topographic diversity and vegetational mosaics. A mesic Jeffrey pine forest in area I includes *Abies concolor* and *Calocedrus decurrens* but also more xeric open patches of *Artemisia tridentata, Cercocarpus ledifolius* and *Juniperus occidentalis*. Areas III and IV are drier, including open slopes, ridges and spurs, with a variety of shrub–woodland elements and slopes forested with Jeffrey pine.

Comparison of methods. Comparison of ground observations (Table 6) and the vegetation map discussed above suggests that different forests may have been under consideration. However, the 2 sets of information are based on methodologies differing in scale of observation, qualifications for inclusion, and extent of coverage.

To reconcile these differences, ground samples were correlated with vegetation map units by determining their location on topographic maps and soil vegetation maps, listing the map vegetation codes at those locations, and applying similar codes to ground vegetation samples (Table 7). The 2 sets of vegetation codes still look somewhat different. However, if the apparent greater heterogeneity of the ground samples, due to the scale of observation, is ameliorated by summing the codes for several samples in each sample area, and if bare ground symbols are added to ground vegetation codes to allow for the different method of recording ground cover, the 2 sets of summation codes (Table 7) are quite similar.

A few differences remain. At Ash Creek, *Calocedrus* is recorded in ground but not in map samples, with a low cover value in one plot (Table 7). This difference is doubtless due to low density sampling variation and perhaps to a sampling location at the edge of mapped vegetation. At Foster Spring, ground samples indicate *P. ponderosa* on benches and gentle slopes and *P. jeffreyi* in cold air drainage ways. However, ground samples code exactly the same as vegetation map samples. Generalizing to the scale of the map, therefore, does result in a slight loss of resolution.

At Hayden Hill, the vegetation map omitted *J. occidentalis* (probably by error) and ground samples included only minimum *P. ponderosa* cover. Observational notes between ground sample plots record occasional cones of *P. ponderosa* on the ground and old stumps of lareg ponderosa trees. Therefore, there is some *P. ponderosa* in the area even though significant occurrence was not recorded in sample plots. Depending on the time of lumbering operations, considerable *P. ponderosa* timber could have been standing at the time of original mapping.

At Johnson Mill, practically identical codes prevail for both ground and map samples.

At Willow Ridge, map codes list *P. ponderosa* and grass cover but ground samples record *P. jeffreyi* and low total cover but not *P. ponderosa* (Table 7). Perhaps *P. ponderosa* was prevalent at the time of map-

TABLE 8. CROWN COVER AND VEGETATION CHARACTERISTICS OF 3 SAMPLE AREAS IN PLUMAS NATIONAL FOREST. I, Forest road S27, 10 mi. N of Beckwourth; II, 0.2 mi. E of Lake Davis, N of Portola; III, Frenchman Lake, 2 mi. W of dam. Headings and notations as in Table 7.

Species	Sample area			Total			
	I	II	III	D	F	C	I.V.
Abies concolor	1.66	125.35	3.57	26	8	158.58	20.4
Calocedrus decurrens	9.50	189.86		27	7	199.36	22.4
Pinus ponderosa	102.49	154.95		55	6	257.44	28.4
Pinus jeffreyi	90.23	53.68	132.64	85	13	276.55	39.5
Juniperus occidentalis	166.18	0.16		5	4	166.34	15.0
Amelanchier pallida	0.08	0.06	5.89	8	5	6.03	5.6
Arctostaphylos patula	32.00	5.66	18.01	62	12	55.67	21.3
Artemisia tridentata	0.39	0.80	35.28	222	7	36.47	35.3
Cercocarpus ledifolius	4.53			16	2	4.53	3.9
Ceanothus velutinus	6.83	5.34	104.96	36	8	117.13	18.9
*Ceanothus prostratus**	80.00	63.00	53.00	14	14	196.00	26.5
Eriogonum marifolium	0.42			35	2	0.42	6.0
Eriogonum ovalifolium	0.12			21	1	0.12	3.4
Haplopappus acaulis	0.07			3	1	0.07	1.2
Haplopappus bloomeri			4.42	80	5	4.42	14.2
Penstemon deustus	0.06		0.01	11	2	0.07	3.0
Phlox sp.	1.89			64	2	1.89	9.6
Purshia tridentata	2.43	0.12	3.21	44	12	5.76	15.9
*Symphoricarpos acutus**	18.00	3.00	0.90	8	8	21.90	9.2
Total	516.88	601.98	389.89	822	119	1508.75	300.1
Number of plots	5	5	5			15	
Average cover	103.38	120.40	77.98			100.58	
Average tree cover	74.01	104.80	32.84			63.88	

ping and was subsequently lumbered out. The presence of *P. ponderosa* on favorable soils about ¼ mi distant might account for the discrepancy between map and ground vegetation codes.

Grass cover values were not recorded at Willow Ridge. Grass patches were noted but bare ground was more prevalent. For practical purposes, in this comparison grass cover and bare ground are equivalent. Correspondence between ground samples and map samples is rather close and lends confidence to their complementary use in regional comparisons.

The Jeffrey Pine Forests of Plumas and Tahoe National Forests. Ground level vegetation samples from 3 forest areas in Plumas National Forest (Table 8) indicate an average cover of 100% and an average tree cover of 64%. Both values are higher than comparable values in the Modoc Forest suggesting a denser vegetation and more mesic conditions. The most important species, on the basis of importance values, include 5 trees and 6 shrubs in the sequence *Pinus jeffreyi, Artemisia tridentata, Pinus ponderosa, Ceanothus prostratus, Calocedrus decurrens, Arctostaphylos patula, Abies concolor, Ceanothus velutinus, Purshia tridentata, Juniperus occidentalis* and *Haplopappus bloomeri.*

Fairly uniform importance values suggest that more than a few species assume dominant roles in the region. The 5 tree species are the same as those in the Modoc Forest. The 14 species of shrubs and suffrutescent plants represent a net increase of 2 species in 15 sample plots as compared with 12 species observed in 33 sample plots in the Modoc Forest.

Greater variety of species and increased dominance of more species, especially shrubs, probably derives from greater gross environmental and topographic variation and greater disturbance in the Plumas Forest.

Topographic variation ranges from the west slope position (high precipitation) of Davis Lake, and the high elevation (2000 m) and near sub-alpine ridges of the mountains north of Beckwourth, to the low broad ridges and volcanic tablelands at Frenchman Lake in a local rain shadow. The general topographic diversity provides several different habitat systems in which different species assume roles of major importance. The compositional differences among the 3 sample areas (Table 8) produce an overall effect of fairly uniform average importance values for the region.

The relative amount of disturbance follows the same sequence: slight disturbance at Davis Lake derives from the management practice of cutting understory white fir; greater disturbance north of Beckwourth derives from current logging, especially construction of logging roads; much greater general disturbance from logging and burning over many years is evident at Frenchman Lake. The variety of successional stages apparent at Frenchman Lake contribute to marked diversity and general openness of the vegetation despite a relatively mesic appearance (compared to the Modoc Forest). Consequently, successional species like *Ceanothus velutinus, Arctostaphylos patula*, and *Ceanothus prostratus,* as well as generalists like *Artesmisia tridentata,* assume greater importance values than they do in the Modoc Forest. The more mesic conditions in the Plumas Forest probably account for the lower importance values of *Cercocarpus ledifolius, Amelanchier pallida,* and perhaps *Purshia tridentata.*

The longevity of disturbance at Frenchman Lake is indicated by the large size of *Ceanothus velutinus* clones (Zavitkovski and Newton 1968), some of which reach 20 m in diameter. An instructive appraisal of the rate of secondary succession might be derived from collation of clone size and age distributions.

Vegetation samples from 5 forest areas in the Tahoe National Forest (including one in Toiyabe N.F.) indicate an average cover of 76% and an average tree cover of 66% (Table 9). This forest is fairly open but considerable heterogeneity among sample areas is evident in cover and composition (Table 9). Relatively mesic conditions are indicated south of Truckee at high elevations by the dominance of *Abies concolor* and the presence of *Pinus lambertiana.* Relatively xeric conditions are indicated south of Carson City at low elevations by the absence of all trees except

TABLE 9. CROWN COVER AREA AND VEGETATION CHARACTERISTICS OF 5 SAMPLE AREAS IN TAHOE AND TOIYOBE NATIONAL FORESTS. I, II, III—Hennes Pass Road, about 15 mi. N of Truckee and respectively 1.5 mi. W, 1.1 mi. E and 5.7 mi. E of State Highway 89; IV—Pole Creek Road, 6 mi. S of Truckee; V—Old Highway U.S. 50, S of Carson City and 2.6 mi. W of U.S. 395. Headings as in Table 7.

Species	Sample area					Total			
	I	II	III	IV	V	D	F	C	I.V.
Pinus lambertiana				9.13		1	1	9.13	1.2
Abies concolor	35.60	1.94	8.30	501.81		59	12	547.65	38.1
Calocedrus decurrens	19.36					7	1	19.36	2.3
Pinus jeffreyi	253.60	292.15	162.51	169.03	300.42	297	30	1177.71	100.9
Juniperus occidentalis		11.04	200.24			15	8	211.28	16.1
Amelanchier pallida			0.06	0.05		7	6	0.11	4.8
Arctostaphylos nevadensis				7.03		5	5	7.03	4.2
Arctostaphylos patula	105.90	2.67	0.01			66	7	108.58	16.0
Artemisia tridentata		2.25	6.09		14.18	203	13	22.52	29.4
Ceanothus cordulatus	4.93			0.02		9	4	4.95	3.9
*Ceanothus prostratus**	57.00	2.25	6.00	4.01		12	12	69.26	12.5
Chrysothamnus nauseosus					0.02	2	3	0.02	2.2
Haplopappus bloomeri	0.75	0.02				26	3	0.77	4.5
Penstemon deustus	0.10					4	1	0.10	1.1
Phlox sp.			1.30	0.01		28	3	1.31	4.8
Purshia tridentata	19.98	3.80	29.29		23.90	277	18	76.97	42.3
Quercus vaccinifolia				0.01		2	2	0.01	1.6
Ribes roezlii			0.63	0.03		4	4	0.66	3.1
Rosa californica	1.00					2	2	1.00	1.6
Symphoricarpos acutus	0.30		1.90	7.05		12	12	9.25	9.8
Total	498.52	316.12	416.33	698.17	338.53	1038	147	2267.67	300.4
Number of plots	6	6	7	6	5		30		
Average cover	83.09	52.69	59.48	116.36	67.83		75.59		
Average tree cover	51.40	50.86	53.01	113.32	60.08		65.50		

TABLE 10. VEGETATION AT DEVIL'S GATE PASS, MONO COUNTY, CALIFORNIA, AUG 1, 1972. Importance values are based on 2 belt transects (A, B), each 50 x 2 m; crown diameters of all shrubs, and trunk diameters of all trees over 2 m high, rooted within the transect area, were measured; small trees were included in determining frequency; otherwise, methods are as in Table 7 to 9; *Ceanothus velutinus* is also common in the area but did not occur on the observed transects.

Species	I.V. A	I.V. B
Pinus jeffreyi	131.8	70.3
Cercocarpus ledifolius	30.4	72.5
Artemisia tridentata	104.2	70.6
Ribes viscosissimum	24.7	9.3
Leptodactylon pungens	8.8	37.6
Symphoricarpos vaccinoides		16.1
Purshia tridentata		15.5
Juniperus occidentalis		8.0
Total plants	47	150

TABLE 11. IMPORTANCE VALUES FOR 3 AREAS NEAR DEADMAN SUMMIT, MONO COUNTY, CALIF. AUG. 1 AND 2 1972. Based on 7 belt transects, 50 x 2 m. I, Lower mountain slopes; II, flat at base of mountain slopes; III, pumic flat, 4 mi. E of summit; *Pinus murrayana* also was common in areas I and III but did not occur on sample plots.

Species	I		II			III	
Abies magnifica	55.8	197.6					
Pinus monticola	39.5	—					
Pinus jeffreyi	204.7	102.4	86.6	150.8	142.9	112.2	97.8
Purshia tridentata			213.4	122.3	103.0	132.4	50.8
Leptodactylon pungens				26.9	54.3	—	7.0
Artemisia tridentata						42.8	88.7
Chrysothamnus parryi						12.7	41.4
Lupinus breweri							14.2

P. jeffreyi. Cold conditions are indicated for the general east Sierra region south of Truckee by the absence of *P. ponderosa* (Haller, 1959). However, north of Truckee the east side ponderosa pines are morphologically and physiologically like those of the interior Pacific Northwest (Haller, pers. comm.). Primarily they are highly cold tolerant and compete well with Jeffery pine. South of Truckee, where ponderosa pine is absent or sparse (for reasons not apparent), *P. jeffreyi* assumes a role of strong dominance, even more exaggerated than in the Modoc Forest. The cold conditions and strong Sierra Nevada rain shadow probably combine to eliminate other species selectively.

The most important species in the Tahoe Forest, based on importance values are, in sequence *Pinus jeffreyi, Purshia tridentata, Abies concolor, Artemisia tridentata, Juniperus occidentalis, Arctostaphylo patula* and *Ceanothus prostratus*.

An increase in the number of shrub and suffrutescent species, as compared to the Modoc and Plumas forests, may be accounted for by the wide elevational range and pronounced rain shadow. Disturbance by fire was evident only in sample area I (Table 9) where *Arctostaphylos patula, Ceanothus cordulatus* and *Ceanothus prostratus* are most prominent (Skau et al., 1970).

Arctostaphylos nevadensis and *Quercus vaccinifolia* in sample plots south of Truckee but not in sampled areas to the north indicate a high elevation forest transitional to the Sierra Nevada red fir forest (Oosting and Billings, 1943). Furthermore, I observed a few red fir (*Abies magnifica*) in the area but not on the sample plots.

Jeffrey pine forests in Mono County. An open stand of Jeffrey pine at Devil's Gate Pass (Table 10) consists of a few large trees with a multiple understory of *Cercocarpus ledifolius, Artemisia,* and *Ribes.* Still farther south in Mono County, an extensive open forest of Jeffrey pine occurs on the high elevation pumice plateau near Deadman Summit where open ground and a shrub understory of *Purshia* and *Artemisia* are significant (Table 11). Toward the base of the Sierra Nevada, Jeffrey pine and *Purshia* increase (Table 11) to positions of strong dominance similar to the sample from Toiyabe National Forest (Table 9, area V). On the steep slopes, Jeffrey pine forests grade into dense forests of red fir with an admixture of western white pine but with virtually no shrub understory (Table 12). Lodgepole pine (*Pinus murrayana*) is common in the region but not in the few transects observed.

Summary and Conclusions

The southern Modoc National Forest was analyzed from vegetation–soil map data that expanded ground observational coverage to over 500 km^2. Information from the vegetation map agreed satisfactorily with ground observations when scale of observation was accounted for. Thus, vegetation map data provide a viable base for quantitative interpretation of vegetation over large areas. The vegetation pattern is one in which forests occur on favorable, deep soils, brush vegetation occurs on poor soils in the basins, and intermediate soils are occupied by open forests and woodlands. The observed gradient places *Abies concolor* and *Calocedrus decurrens* in deep soils at the most mesic end of the vegetation gradient. *Pinus ponderosa, P. jeffreyi* and *Juniperus occidentalis* occur respectively along the gradient of decreasing soil depth and quality until only brush species, *Artemisia tridentata,* and finally *A. arbuscula,* occur on the shallowest, poorest soils.

Pinus jeffreyi occurs in pure stands, i.e., without other tree species, with a frequency of only 16%, and *P. ponderosa* occurs in pure stands with a frequency of only 8%. More often they occur in mixed forests and Jeffrey pine also occurs with *Juniperus occidentalis* in open forests or woodlands.

The pattern of vegetational distribution is mediated by soil characteristics but complicated by other factors such as successional status and management practices. Woody shrubs may have roles in secondary succession and their fairly low frequencies except on volcanic ridges suggests that the Modoc Forest is generally stable and relatively undisturbed. Logging over the years may have influenced some compositional changes in the forest. Primarily, *Pinus ponderosa* seems less prominent now than indicated on the vegetation map compiled in 1953, at least in 2 specific localities. Such compositional changes, mediated by lumbering, render difficult the interpretation of the forest in terms of natural plant communities. Nevertheless, those forests are the *de facto* communities and bear considerable resemblance to pristine vegetation.

The southern Modoc Forest was compared to forests with Jeffrey pine in the Plumas and Tahoe Forests to the south. Each forest has its range of characteristics with respect to cover, important species, diversity of species and successional status.

In broad terms, Jeffrey pine forests range along at least 2 general gradients, both modified by altitudinal variation. One gradient proceeds essentially west–east and is influenced by decreasing moisture associated with the Sierran rain shadow. Depending on elevation, the more mesic forest to the west is either a red fir or Sierra Nevada ponderosa pine forest. The more xeric vegetation to the east is either a western juniper woodland or Great Basin sagebrush.

The second gradient runs north–south and is probably primarily influenced by temperature. The major range for Jeffrey pine occurs to the south where it occupies a broader elevational range (Haller, 1959). Jeffrey pine as a forest type stops north of the southern Modoc Forest study region. Still further north Jeffrey pine occurs mainly as an element of ponderosa pine forests. However, patches of Jeffrey pine occur in the Warner Mountains (Milligan, 1969) in forests considered to be depauperate Sierran forests by Critchfield and Allenbaugh (1969). Vegetation of the Warner Mountains is considered to be transitional to the Great Basin (Milligan, 1969) and cold dry conditions appear limiting to the northeast. To the northwest, however, excessive moisture may be limiting. Haller (1959) indicates more rapid growth by ponderosa than by Jeffrey pine in areas of ample moisture. The southern Oregon limit for Jeffrey pine on serpentine (Whittaker, 1960) may be instructive in this regard. Thus, the northern range of Jeffrey pine seems limited where conflicting moisture–temperature gradients meet and are superceded by other factors.

The *narrow* occurrence of unmixed Jeffrey pine on a broad gradient in the Modoc Forest may be a consequence of its position near the northern limits of its range. Therefore, relative breadth of occurrence on a gradient toward the center of the range of distribution should be determined in addressing the question of whether Jeffrey pine forests merit widespread recognition as a separate community or whether they represent merely a phase of the mixed conifer forest.

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THREE NEW SPECIES OF JATROPHA (EUPHORBIACEAE) FROM WESTERN MEXICO

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In the course of field studies for an infrageneric revision of the genus *Jatropha* (Dehgan, 1976), three Mexican collections—two from Baja California and one from Jalisco—were found to differ from all species previously described from these areas (Mueller, 1866; Pax, 1910; Standley, 1923; McVaugh, 1945a, 1945b; Wilbur, 1954; Shreve and Wiggins, 1964). Following are descriptions of these taxa and comparisons with related species. Since all three species were either dormant or at least not flowering at the time of collection, cuttings and/or seedlings were grown to maturity in the greenhouse. The descriptions that follow are therefore based primarily on these greenhouse plants.

1. **Jatropha giffordiana** Dehgan and Webster, sp. nov. sect. *Loureira* subsect. *Canescentes;* a *J. canescenti* et *J. cinerea* differt foliis glabriusculis exstipulatis, inflorescentia ♂ florem ♀ solitarium efferenti, petalis rubris, pistillo 3-loculato, stylis 2 stigmatibus multifidis (Figs. 1–7).

Shrub ca 1–1.5 m high; caudex thickened, stem and branches succulent, branches spreading and decumbent; bark fissured and peeling on older branches; short shoots numerous and distinct on older branches, 2–5 cm long, pubescent, with small leaves crowded near the apex. *Leaf*-with-petiole 3.5–8.5 cm long, 3–7 cm wide; stipules not evident; blade broadly ovate, unlobed, entire (completely devoid of glands), pubescent on the veins abaxially but otherwise glabrous, palmatinerved with five prominent and two weaker lateral veins, cordate at base, acute at apex. *Inflorescences* gynodioecious, terminal on branches or more often on short shoots, the plants pistillate and staminate; in the staminate racemose-paniculate, with many ♂ flowers and one central ♀ flower; pistillate inflorescence racemose, of 2–5 flowers; axis villose, ca 5–12 cm long in the male and 1.5–2.5 cm in the female; paracladia mostly 2–4 cm long in